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STUDY OF SPEED INCREASE OF HUNGARIAN FREIGHT TRAINS

Gyorgy Csanadi

/Figures are appended./

A problem of general interest has lately become a matter of discussion among technicians and economists. The controversial point is whether or not the present standard speed of Hungarian freight trains should be increased. This question has been brought up repeatedly in various conferences, service meetings, and professional publications and has led to a great deal of misunderstanding. The source of these misunderstandings is the fact that according to railway business calculation there is, under given technical conditions, a maximum standard speed for freight trains which appears to be the optimum speed from an economic point of view.

The speed of bulk freight, which represents the majority of railroad freight and is therefore the foremost concern of railroads, showed very little progress on the Hungarian railroads. Some progress has been achieved during the last few years; the average speed of freight, for instance, was improved by 15 percent during the last 2 months. Despite this fact, the average speed including stops of all freight trains is still only 14 kilometers per hour, and the average speed including layovers (kozlekedesi sebesseg) of freight cars only 2.5 kilometers per hour, while in the USSR the average speed including stops of freight trains is 20 kilometers per hour, and the average speed including layovers of freight cars 6 kilometers per hour.

The speed including stops of freight trains can be accelerated by increasing their standard speed, but it can also be done by technical development and rationalization without an increase in the standard speed. An example of the practical applicability of this has been given by the USSR, where the ratio of average speed including stops to average standard speed is 0.62, in contrast to only 0.4 in Hungary.

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The problem of speed of freight trains should first be examined in relation to operating cost. It may be mentioned that determining the "optimum speed" is a complicated task which can be achieved only with approximate accuracy. Generally speaking, it varies with locomotive type, load distribution, and weight of the train. The following analysis will be concerned with steam-traction freight trains as a group, without considering details of locomotive type and varying track grades. It would be of no practical value to include electric-traction trains in this analysis, because the speed standards of electric trains are technically fixed. In our analysis, we use expense data worked out according to the new accounting system which was adopted by the Hungarian State Railroads in July 1951, following the example of the USSR.

In making a comparison of the operating costs of freight trains with different standard speeds it is not necessary to assess numerically all components of operating costs; following V. N. Orlov's system of calculation, it is sufficient to deal only with those expense items which show different amounts for different standard speeds. Among these items, coal-consumption expenses will be considered first.

The variation in coal-consumption expenses is due to the fact that, with increasing speed, the train resistance which has to be overcome increases. The specific resistance W of loaded freight cars hauled on a grade of zero percent is calculated by the Hungarian state Railroads by the following formula.

$$W = 2.5 + \frac{V^2}{2000}$$

(The resistance of empty cars is 20 percent higher than this, and each percent of grade means an additional resistance of one kilogram per ton.)

By applying this formula to various speeds the values shown in Figure 1 were obtained.

The resistance of steam locomotives has been calculated on the basis of the following formula:

$$Zm = (Lf + T)\,(1.8 + 0.010\,V) + A\,(a + \frac{b}{D}\,V) + 0.006F\,V^2), \text{ where:}$$

Lf = weight on trailing wheels (for Type 424 locomotive, 26 tons)

T = weight of the tender (for Type 424 locomotive, 41.8 tons)

V = speed in kilometers per hour

A = weight on drivers (for Type 424 locomotive, 57.2 tons)

a = constant (for Type 424 locomotive, 8)

b = constant (for Type 424 locomotive, 0.18)

D = driving wheel diameter (for Type 424 locomotive, 1,606 millimeters)

F = front surface (for Type 424 locomotive, 10 square meters)

The specific resistance of the Type 424 locomotive, obtained by applying the above formula to the specified values, is shown in Figure 2 for various freight train speeds.

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With increasing speed, greater tractive effort is naturally required to overcome resistance, resulting in additional specific coal consumption. For trains hauled by a Type 424 locomotive on Load Division I (2 percent grade), the standard consumption applicable to hauled gross units and calculated as a function of load at various speeds is presented in Figure 3.

Figure 4 shows standard coal consumption for the self-propulsion of Type 424 locomotive on Load Division I (2 percent grade), per kilometer instead of per 100 gross ton-kilometers (since Type 424 locomotives weigh 125 tons, the coal consumption per 100 gross ton-kilometers is 1.25 times the indicated values).

The figures clearly show the increasing specific coal consumption at increasing speed for equal train weights. Looking at the lower part of the graph in Figure 3, we find the curves have a lowest point. When the locomotive hauls a train exceeding the weight indicated by the lowest point, its specific coal consumption increases.

According to Figure 3, a train pulling a load of 1,000 tons at an average speed of 60 kilometers per hour has an additional average coal consumption of 1.4 kilograms (37.8 percent) as compared to a train traveling at an average of 30 kilometers per hour, a train with an average speed of 50 kilometers per hour requires an additional 0.7 kilograms (18.9 percent) and a train traveling at an average speed of 40 kilometers per hour 0.2 kilogram (5.4 percent). Pulling a load of 1,400 tons a train with an average speed of 40 kilometers per hour has a specific consumption 0.4 kilogram (10.8 percent) in excess of that of a train traveling at an average speed of 30 kilometers per hour.

If we examine specific coal consumption at the regular load established in the appendix to the traffic schedule, we find the following values for excess coal consumption:

Excess Coal Consumption in Kilograms (and in Percent), at Various Speeds and Loads

At a speed of:	60 km/hr	50 km/hr	40 km/hr	30 km/hr	
and a load of:	1,000 tons	1,400 tons	1,600 tons	1,700 tons	
excess coal consumption amounts to (kg)	.2 (4.1%)	-	-	-	compared with a speed of 50 km/hr
	1.0 (24.4%)	.8 (19.5%)	-	-	40 "
	1.25 (32.5%)	1.05 (27.3%)	.25 (6.5%)	-	30 "

The specific coal consumption was computed for haulage on a 2 percent grade at a constant speed (without acceleration).

Let us see some results of actual calculations. To check the correctness of calculated specific coal consumption values, we present the following table with pertinent data on two double test runs on load and consumption. The test runs were made last summer by an experimental team of the Hungarian State Railroads on an instrument car and the team's own train hauled by a Type 424 locomotive. The load in each case was 34-35 percent more than the locomotive's regular load.

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	Test Run I Szolnok-Debrecen Route		Test Run II Nyiregyhaza-Debrecen Route	
Load (tons)	2160	1341	2046	1283.5
Average speed (km/hr)	40	60	30	50
Average coal consumption per gross ton-km (kg)	2.48	3.24	2.65	3.88
Effective horsepower-hours	2548.5	1684.9	905.0	683.3
Average coal consumption per effective horspower-hour kilogram	2.36	3.10	2.90	3.76

According to data of Test Run I, specific coal consumption at 60 kilometers per hour exceeded consumption at 40 kilometers per hour by 0.76 kilogram (30.6 percent) per gross ton-kilometer and 0.74 kilogram (31.4 percent) per effective horsepower-hour.

According to data of Test Run II, the excess specific coal consumption at 50 kilometers per hour is 1.23 kilograms (46.5 percent) and 0.86 kilogram (29.7 percent). respectively, compared to a train with an average speed of 30 kilometers per hour.

The consumption data do not include the coal required for initial firing, heating up, pulling in and out, switching, etc.

For the average freight-train load, the excess coal consumption of all steam locomotives of the Hungarian State Railroads shows the following minimum values depending on average speed:

Excess Coal Consumption, in Kilograms per 100 Gross Ton-Kilometers, at Various Speeds

At a speed of	60 km/hr	50 km/hr	40 km/hr	30 km/hr	
excess coal consumption amounts to (kg per 100 gross ton-km)	.2	-	-	-	compared with a speed of 50 km/hr
	1.0	.8	-	-	40 "
	1.25	1.05	.25	-	30 "
	1.38	1.18	.38	.13	20 "

The maintenance cost of the car bodies undoubtedly grows with increasing train speed. However, the increase is not considerable for the speeds investigated and moreover there is no way, at the time being, of determining it quantitatively. We shall therefore omit this factor. This factor has not been sufficiently evaluated in the USSR.

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It can be stated that the optimum speed is approximately 30 kilometers per hour for freight trains operating exclusively or partially with hand brakes. This is the present situation. On much-used single-track lines, a speed of 40 kilometers per hour is justified even for hand-brake operated trains, if blocking or shunting of trains can thereby be reduced.

A speed increase is particularly justified for servicing and switching freight trains, since their load is usually below average.

The optimum speed for trains with air brakes is approximately 40 kilometers per hour. It is therefore advisable to adopt a standard speed of 40 kilometers per hour after air brake equipment has been introduced. Even a standard speed of 50 kilometers per hour does not involve a considerable increase in operating cost. Such a standard speed can be considered especially on main lines and on secondary lines with gentle grades.

In the absence of an analysis which includes all types of steam locomotives, we calculated the increase in operating cost due to the effect of speed increase on specific coal consumption by using data applicable only to the Type 424 locomotive. The increase in operating cost due to specific coal consumption for all kinds of locomotives is certainly larger than the values presented in the table above.

Available statistics indicate the following correlation in the speed of stream-traction freight trains (in kilometers per hour):

Speed Including Stops	Speed Excluding Stops
12	30
16	40
19	50
21	60

Since trains run at various speeds excluding stops, the in speeds including stops merely indicate the number of freight trains which can be run on a line but do not determine, in themselves, the traffic capacity of lines as far as gross or net freight is concerned, which is obviously what matters from the viewpoint of capacity. It is therefore necessary to examine the effect of change in speed excluding stops on the weight of trains. At the lower limit of the Load Division III (5 percent grade) the standard load of the most frequently used freight-train steam locomotives will show the following comparative values (assuming that the load is 100 at 30 kilometers per hour).

Speed Excluding Stops (km/hr)	Type of Locomotive					Acceptable Average
	411	324	424	375	376	
30	100	100	100	100	100	100
40	79	92	96	81	81	84
50	60	79	89	63	61	65
60	45	54	64	43	--	50

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If we multiply the speeds including stops corresponding to the various speeds excluding stops by the average values shown above, we obtain the following results:

For speed excluding stops of	30 km/hr :	12 x 100	1,200
	40 km/hr :	16 x 84	1,344
	50 km/hr :	19 x 65	1,235
	60 km/hr :	21 x 50	1,050

It follows from these results that the traffic capacity of lines is best if freight trains are run at 40 kilometers per hour.

It is therefore absolutely necessary and justified to increase the speed, excluding stops, of freight trains to 40 kilometers per hour if railway lines are overcrowded due to heavy traffic. This is especially applicable to single-track lines with dense traffic.

The decrease in haulage capacity as a function of increase in speed is smallest for Type 424 locomotives. When such locomotives are used, the traffic capacity of lines shows an increase of 28 percent at 40 kilometers per hour, 41 percent at 50 kilometers per hour, and 12 percent at 60 kilometers per hour, as compared to a speed excluding stops of 30 kilometers per hour.

Considering that the average distance covered by a freight train is 140 kilometers and adding 48 percent for empty-running cars (32.5 percent of total car runs), we have 207 kilometers, a distance covered in $\frac{207}{12}$ or 17.3 hours by a car hauled in a train with a speed excluding stops of 30 kilometers per hour, in 13 hours at 40 kilometers per hour, in 10.8 hours at 50 kilometers per hour, and in 9.9 hours at 60 kilometers per hour. Considering that the yearly average turnaround time per car is 5 days or 120 hours, it follows that if the speed excluding stops of freight trains is increased from 30 kilometers per hour to 40 kilometers per hour, the capacity of freight cars increases by $\frac{4.3 \times 100}{120}$ or 3.6 percent; if it is increased to 50 kilometers per hour, the capacity of freight cars increases by 5.4 percent; and if it is increased to 60 kilometers per hour, the capacity of freight cars increases by 6.2 percent.

During peak traffic conditions when the car turnaround time is reduced by various measures, the comparative increase in freight-car capacity which can be obtained by increasing speed excluding stops is considerably higher. In the case of 3.5-day turnaround, for instance, the values are as follows: 5.7 percent for a speed excluding stops of 40 kilometers per hour; 7.7 percent for a speed excluding stops of 50 kilometers per hour; and 8.8 percent for a speed excluding stops of 60 kilometers per hour.

From the viewpoint of increase in freight capacity, the availability of locomotives is affected by the freight train speed excluding stops in the same way as already discussed with respect to the traffic capacity of lines. The traffic capacity of lines is best at a speed excluding stops of 40 kilometers per hour (50 kilometers per hour for Type 424 locomotives). If we disist from utilizing the maximum permissible uninterrupted working time of personnel; if, that is, we assume that the locomotives are returned from terminals with relief crews, the values for the capacity of locomotives will be the same as those presented above.

However, the actual situation, entirely justified from the point of view of service management, is such that the locomotives are sent back from terminals with the original crews and not with relief crews, even if the crew's

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rest period causes the locomotive to suffer delay. This is where the difference between locomotive capacity and train capacity in relation to speed becomes apparent. To illustrate this, let us assume that a freight train runs on a section of 100 kilometers at a speed excluding stops of 30 kilometers per hour. According to the above statements, the net running time of the train will be $\frac{100}{12}$ or 8.33 hours. As far as working hours of the locomotive personnel are concerned, we must add the 2 - 2.5 hours required before the start for getting the locomotive ready, coupling the train, etc. It follows that the engine crew will arrive at the terminal after having worked about 11 hours without rest, and therefore cannot return. If, however, the same section has been covered by a freight train traveling at a speed excluding stops of 60 kilometers per hour, the personnel arrives at the terminal after $\frac{100}{21} + 2 = 6.76$ working hours and can run a train starting immediately with a similar quick schedule back to their home station, because their working time on return will be $2 + 4.76 + 1 + 4.76 = 12.52$ hours, which is still permissible. In such manner the capacity of locomotives can be considerably increased by choosing speeds excluding stops according to the length of section.

We shall not deal with the effect of speed excluding stops on other factors of freight capacity, especially on labor, because this has been illustrated by what has been said above.

In summing up our findings regarding capacity, it can be stated that from the viewpoint of gross traffic capacity of lines the best speed excluding stops for freight trains is 40 kilometers per hour.

The average speed excluding stops of freight trains, in addition to its basic influence on operating cost and operating capacity of railroads, also affects the speed of freight dispatch.

It has already been shown, however, that increasing the speed excluding stops of freight trains is not the only means of accelerating the process of freight dispatch. To confirm this, I would now like to point out that in our present situation freight cars with a 5-day turnaround time spend only ($\frac{15}{120} \times 100$) 12-13 percent of their useful time (car-hours) and those with a 3-day turnaround time only ($\frac{15}{72} \times 100$) 20-21 percent on actual transportation.

This clearly shows that from the point of view of accelerating the car turnaround and especially its loaded phase, the increase in speed excluding stops is not the only matter of interest.

In connection with this, I also want to point out that the change in the speed of freight dispatch is not identical with the change in speed of the car turnaround time, since on the one hand the cars -- in their empty state -- have a certain time lag independent of speed (when the cars, after being loaded or unloaded, have to wait for the train which will forward them); on the other hand, there is also a time lag for the freight in connection with making it ready for transport and moving it to and from the train, which will affect the change in freight-dispatch time independently of the speed of freight trains.

There are no data available yet to enable us to undertake an exact evaluation of these factors. We can, however, accept as a rule that when the speed excluding stops of freight trains is raised, the increase in the speed of freight dispatch, in conjunction with a decrease in car turnaround time, will be larger if the freight has to wait less for freight cars than the freight cars wait for loading. Since this is usually the case in Hungary, it can be stated that the increase in speed excluding stops affects the speed of freight dispatch to a larger degree than it does the average speed of cars.

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It appears from the above that under conditions prevailing in Hungary the increase in speed excluding stops of freight trains is accompanied by a considerable acceleration of freight dispatch, although it has not been possible so far to give a numerical analysis of this value.

In conclusion, we should now find an answer to the question of whether it is necessary to increase the present 30-kilometer-per-hour average speed excluding stops of freight trains.

The question could be put in an even more general way: What measures should be adopted to achieve acceleration of Hungarian railroad freight, which is absolutely necessary?

It must be emphasized that the ruling principle of this problem is the interest of the entire national economy, which urgently requires that we eliminate our present backwardness without delay and accelerate Hungarian railroad freight. Every possible means should be used to achieve this aim. Accordingly:

1. The present norms for making up trains, loading, unloading, and operating must be improved considerably. This can be achieved by technical development, by new installations, by most extensive mechanization, and by adopting new socialist work methods. Naturally this task can be effectively pursued only if the sectors of the national economy outside of railway management cooperate, recognizing and promoting the common economic interest. No satisfactory results can be obtained in technical development, socialist work methods, or rational organization unless customers cooperate with the railway management in the enlargement and modernization of transport facilities in their depots, mechanical devices for moving merchandise, smooth and more systematic disposal of goods, and rational organization of work. Acceleration of the work phases of making up trains, loading, unloading, and operating consequently requires a mutual effort in all important production branches and railways. We are entitled to expect unusually big results from such efforts, which can free immense hidden reserves and are therefore one of the main fields toward which our diligence in accelerating railway freight should be directed.

2. The speed, including stops of freight trains in relation to their speed excluding stops must be improved considerably. This is essentially an internal problem of railway management. In other words, railway traffic organization and dispatch is still far from having exploited all hidden reserves in the form of delays and idle freight trains. The ratio of speed excluding stops to speed including stops is 0.4 in Hungary, in contrast to a ratio of 0.62 for the Soviet railways. This clearly shows that there is still much unnecessary delay, which can be reduced considerably by better traffic organization and more disciplined and circumspect dispatch. Of course, improvement in this factor also depends on technical considerations; therefore, it should be an important task of our technical development to eliminate those bottlenecks which still hamper the quick movement of trains. In this field, major attention should be given to the problem of servicing trains which have the most unfavorable speed including stops. The best policy is to increase speed including stops considerably without forgetting that a freight train has to take care of all operations along the line. It would be extremely unprofitable to accomplish acceleration of trains at the expense of leaving some of the operations along the line undone.

3. As a third measure of accelerating railway freight, an increase in freight train speed excluding stops can be applied. To sum up the results of our analysis of this problem, I would like to state again that the optimum speed of freight trains with hand brakes is at present 30 kilometers per hour, which is the standard speed (excluding stops) now in practice; for freight trains with air brakes, however, the profitable speed is 40 kilometers per

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hour; on crowded single track lines a standard speed of 40 kilometers per hour is justified to reduce shunting delay. From the viewpoint of traffic capacity of railroad lines -- in relation to lines as well as locomotives and cars -- a standard speed of 40 kilometers per hour is usually justified.

Considering all this, it appears that the operating cost factor of freight trains with hand brakes is practically the only argument in favor of the present standard speed excluding stops) of 30 kilometers per hour; on the other hand, it is true that the bulk of railway freight is still handled by such trains.

We should not disregard the fact that in a socialist economy there is no such thing as self-interested business objectives. Applied to railways, this means that if the acceleration of freight results in a gain to the national economy larger than the loss to the national economy resulting from an increase in railway operating cost, the speed of freight must be increased by using speeds even beyond the optimum speed, as long as the increase in speed excluding stops does not compromise the required capacity of the railway.

It should be further noted that the concept of optimum speed changes according to technical development. Evidence of this is the fact that, for instance, the optimum speed of freight trains will be 40 kilometers per hour as soon as air brakes are used exclusively; this is planned for the near future. Similar changes result from the development of available locomotives, etc. This means that the value of optimum speed calculated at a given moment can become obsolete at another moment -- perhaps within a brief period of time. Since the technical development of the Hungarian State Railroads is rapidly progressing, it is evident that the position taken in regard to the problem of the speed excluding stops of freight trains is subject to change. We can definitely state, however, that it is much less justified today to adhere to tne 30-kilometer-per-hour freight-train speed limit, excluding stops, than it was even one year ago.

In addition, it should be pointed out that the numerically apparent optimum speed advantage -- although this is an important factor -- is not the only consideration in deciding on essential issues of national economy. To let this consideration alone prevail means to apply bourgeois methods to transport economics, as the Soviet author P. Krilov recently pointed out in a very valuable critical paper dealing with certain essays on railway economics published in the USSR. (Magyar-Szovjet Kozgazdassagi Szemle, No 7, 1950).

After due consideration of all these facts, it is my opinion that in the interest of accelerated railroad freight, the Hungarian State Railroads should increase the present 30-kilometer-per-hour speed excluding stops of their freight trains.

* * *

The following tabl snows the cost calculation of various pertinent items, in regard to incr asing the speed excluding stops.

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Operating Cost Increase or Decrease in Relation to a Speed Excluding Stops of 20 Kilometers per Hour (in fillers)

	Speed Excluding Stops (km/hr)			
	30	40	50	60
Coal expense	+ 1.56	+ 4.56	+ 14.16	+ 16.56
Coal transport and handling	+ 0.23	+ 0.68	+ 2.13	+ 2.49
Water and boiler washing	+ 0.05	+ 0.14	+ 0.42	+ 0.50
Cinder, smoke, tube heating, blow-off	+ 0.04	+ 0.11	+ 0.36	+ 0.42
Engine personnel, train conductor, etc.	+ 4.10	- 4.10	-15.90	-10.80
Brakemen	+ 1.00	+ 7.90	+11.10	+19.50
Lubricant, etc.	+ 0.55	+ 1.70	+ 3.80	+ 5.95
Locomotive general overhaul	- 0.60	-	5.00	+ 7.30
Locomotive general inspection	- 0.20	-	- 0.80	-
Locomotive driving-mechanism repair and inspection	+ 0.60	+ 1.60	+ 3.30	+ 5.40
Freight-car repair	- 1.32	- 3.31	- 4.27	- 4.58
Car amortization	- 1.60	- 3.90	- 5.06	- 5.57
Locomotive amortization	- 0.53	+ 0.07	- 1.33	+ 0.90
Total	- 4.32	+ 5.45	+12.91	+38.07
Waiting time during trips	- 5.00	- 8.00	-10.00	-12.00
Grand total	- 9.32	- 2.55	+ 2.91	+26.07

/Appended figures follow./

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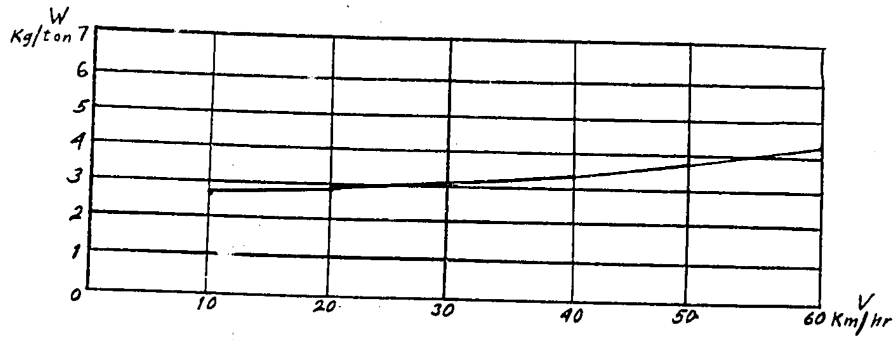

Figure 1. Specific Resistance W of Loaded Freight Cars at Various Speeds V

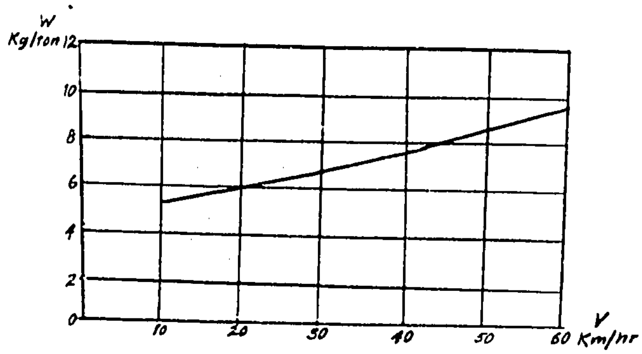

Figure 2. Specific Resistance W of Type 424 Locomotive at Various Freight Train Speeds V

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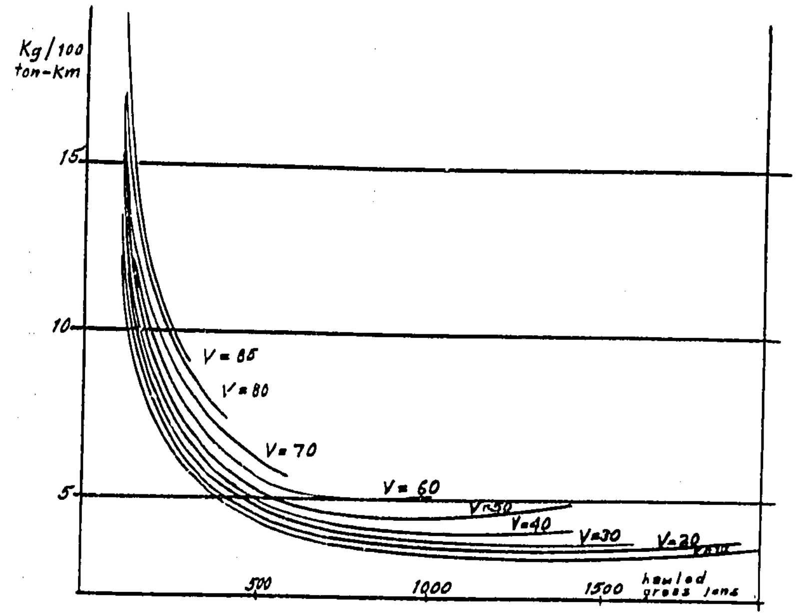

Figure 3. Total Coal Consumption for Type 424 Locomotive per 100 Gross Ton-Kilometers

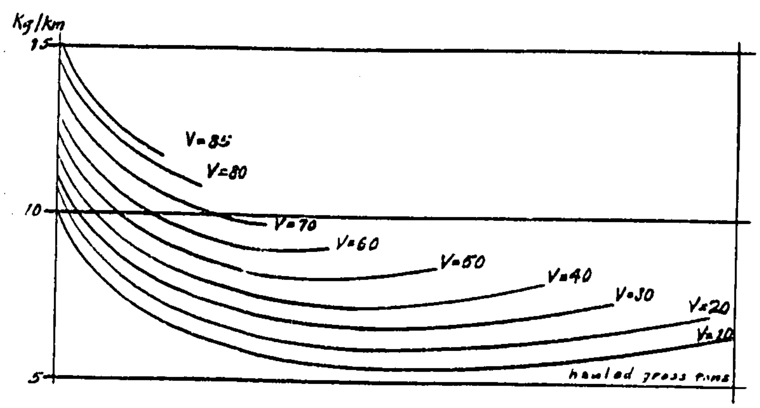

Figure 4. Average Coal Consumption for Type 424 Locomotive in Motion per Kilometer

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